Assignment-3

Subject: Remote Sensing and GIS in Water Resources Engineering

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Dataset and Setup

Seven Landsat TM bands (1–7) were read from `band1.jpg` to `band7.jpg`, cast to `double` for computation, and used to generate the required analyses. Additional composites and PCA products were produced for the challenge items.

Q1. Histograms of All Images

For each band, a full 0–255 intensity histogram was plotted using `imhist` to inspect tone distributions and dynamic range. Coastal water produced low-level peaks in Band 4, while MIR bands showed broader spreads consistent with terrain moisture and lithology differences. The sequential figures titled "Band k Histogram" ($k = 1 \ldots 7$) support threshold selection and contrast decisions by revealing skewness and saturation at the extremes where present.

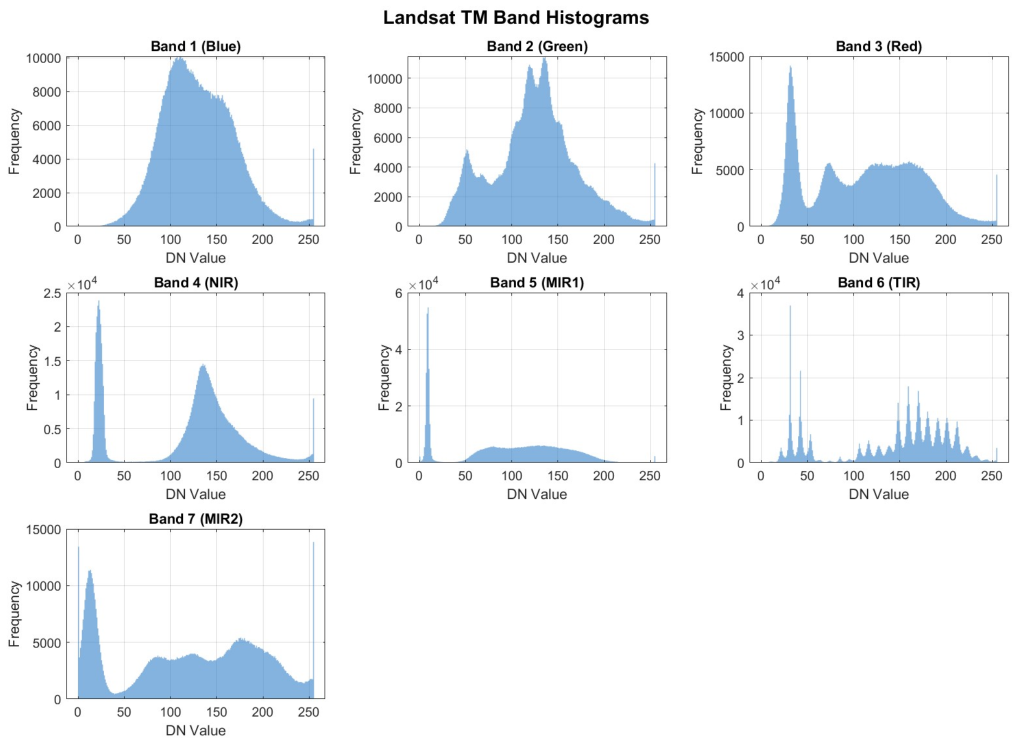

Figure 1: Combined histograms of all seven Landsat TM bands (1–7).

Q2. Scatter Plot: Band 3 vs Band 4

A pixelwise scatter of Red (Band 3) on the x-axis versus NIR (Band 4) on the y-axis highlights spectral groupings. Vegetation clusters in the upper-left due to low red absorption and high NIR reflectance; water clusters in the lower-left with low reflectance in both; urban or bare soils align along a rising diagonal. Axis limits were set to 0–257 with a square aspect to preserve slope interpretation, and the plot was lightly alpha-blended to handle dense pixel clouds.

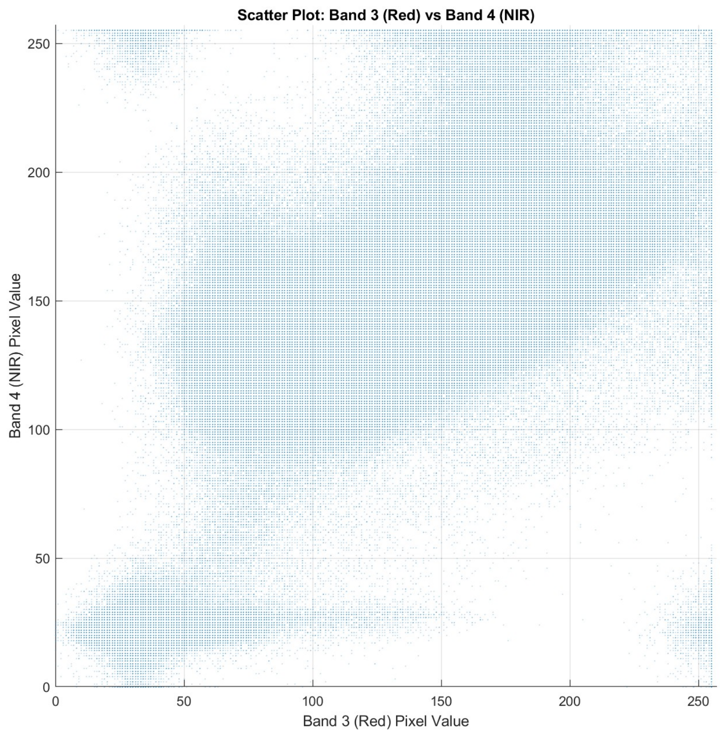

Figure 2: Scattered plot of band 3 and band 4

Q3. Contrast Stretching Bands 3 and 4

Linear stretching using `stretchlim` at the 2–98 percentile was applied to Bands 3 and 4 to expand usable dynamic range. Side-by-side panels show improved separation of shoreline, vegetation, and built-up areas after stretching. The enhancement deepens shadows and brightens highlights without altering radiometric ordering, thus aiding visual interpretation for subsequent mapping steps.

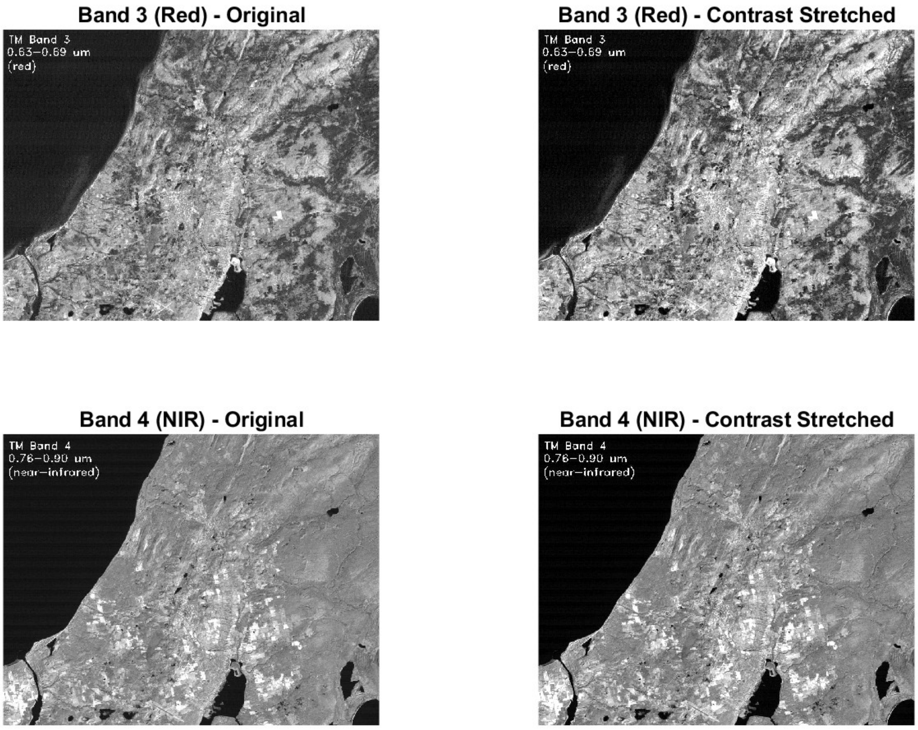

Figure 3: contrast stretch image of band 3 and band 4

Q4. FCC Pixel at (15,45) and Comment

Standard FCC uses RGB = (Band 3, Band 2, Band 1). The sampled pixel at row 15, column 45 reported Band 3 (Red), Band 2 (Green), and Band 1 (Blue) intensities from the respective arrays in the script output are 33 , 33, 111.relatively lower red/green and moderate blue response, suggesting clear or shaded water at that location under standard color interpretation for coastal scenes.

Q5. NDVI Image with Colorbar

NDVI was computed as:

$$\mathrm{NDVI} = \frac{\mathrm{Band}_4 - \mathrm{Band}_3}{\mathrm{Band}_4 + \mathrm{Band}_3 + \varepsilon}$$

and displayed with a `jet` colormap and limits of $[-1, 1]$ An additional classified NDVI view labeled *Water, Bare Soil, Low, Moderate,* and *Dense Vegetation* provides quick thematic interpretation. The console notes summarize class ranges: Water (< 0), Bare soil (0–0.2), Vegetation (> 0.2), aligning with expected spectral behavior over coastal landscapes.

0.1

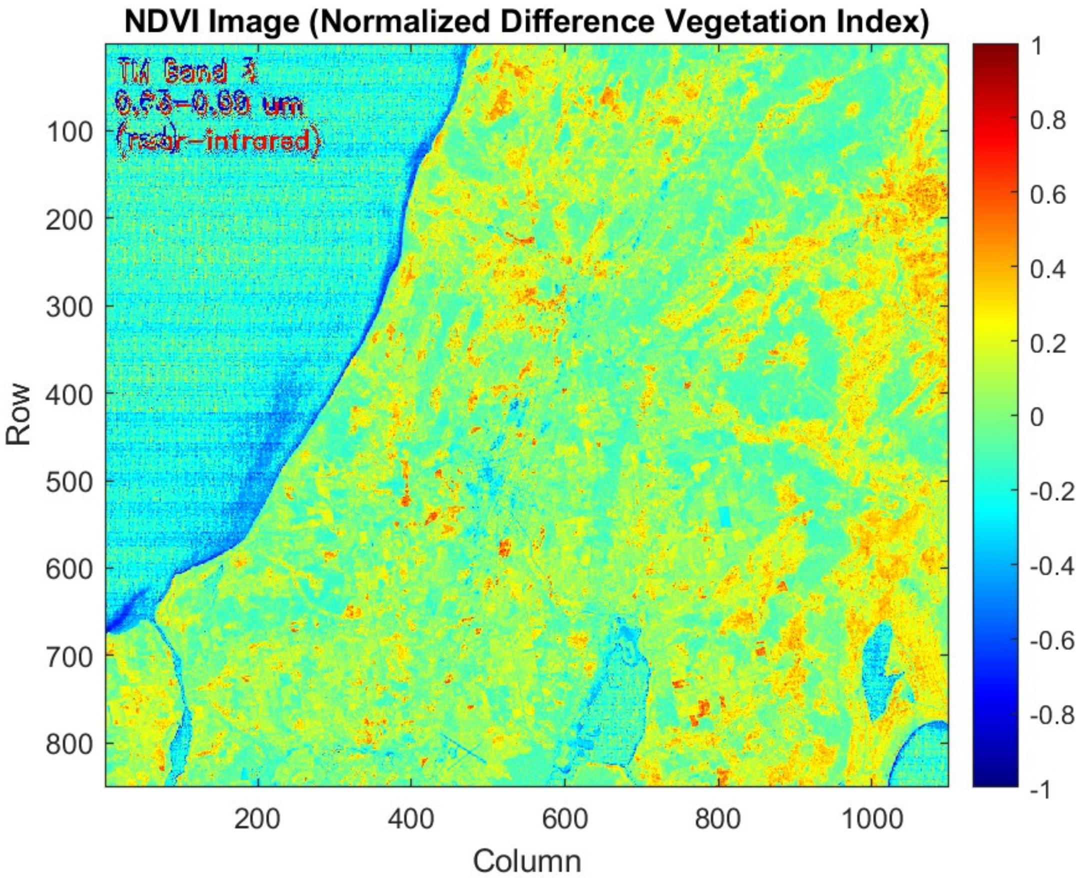

Figure 4: ndvi image with colour bar

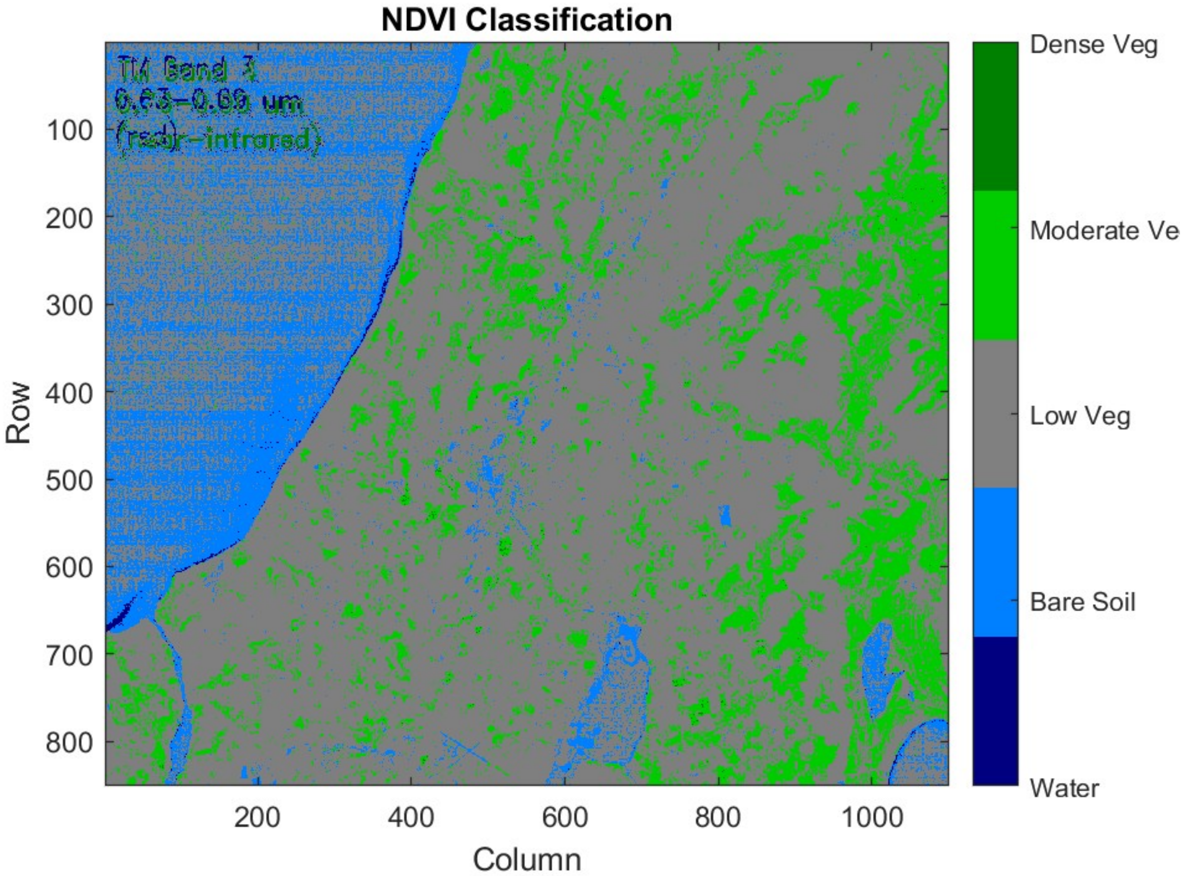

Figure 5: NDVI image with color bar

Q6. Band 5 – Band 4 Image

A difference image

$$D = \text{Band}_5 - \text{Band}_4$$

was rendered in grayscale to emphasize moisture and mineralogical contrasts. Higher positive values generally indicate drier or more reflective SWIR targets relative to NIR, while lower values correspond to wetter or vegetated surfaces. This layer is useful for highlighting soil moisture gradients, tidal flats, and lithologic boundaries in the coastal zone.

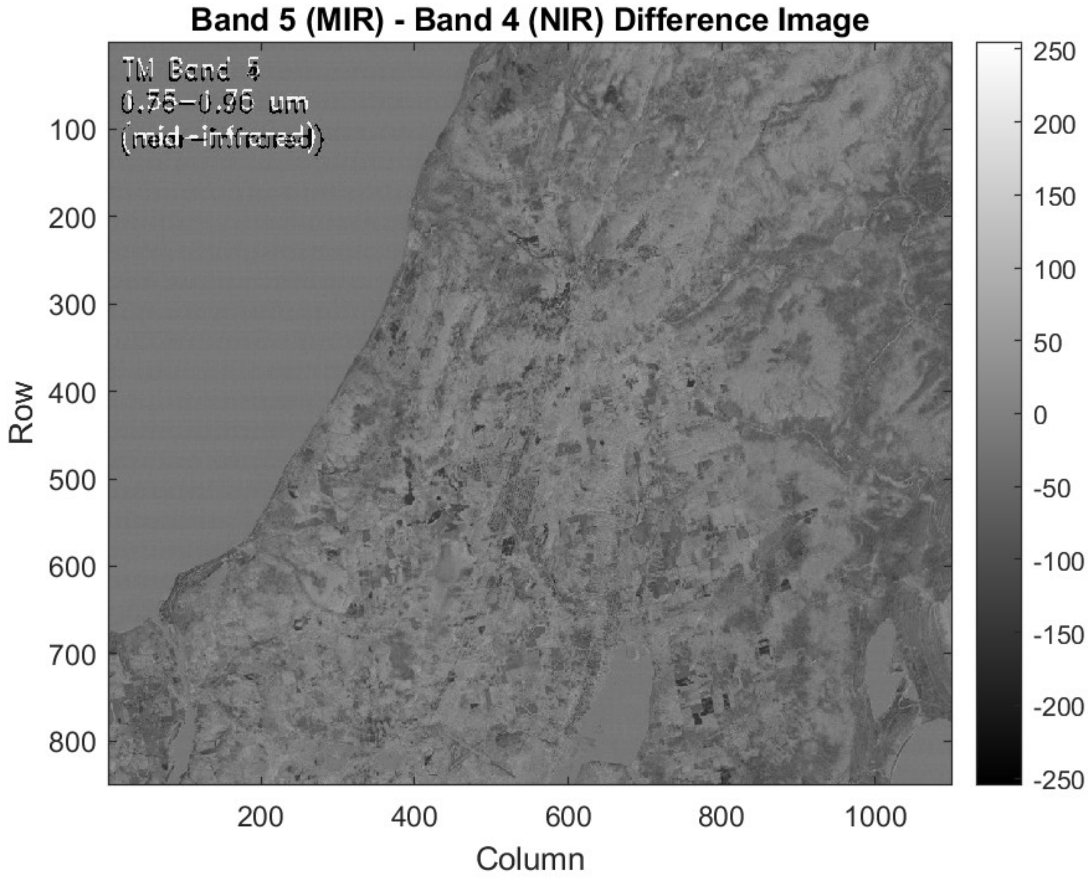

Figure 6: band 5 - band 4

Q7. Water Area from Band 4

Water was mapped by Otsu thresholding of Band 4 (scaled to 0–255), with pixels below the threshold labeled as water. The mask was visualized and overlaid as cyan boundaries on a stretched RGB composite for sanity checking. With 30 m pixels, area was computed as:

$$\text{Water Area} = N_{\text{water pixels}} \times (30 \text{ m} \times 30 \text{ m})$$

and reported in both m^2 and km^2, providing an approximate estimate for water bodies in the scene.

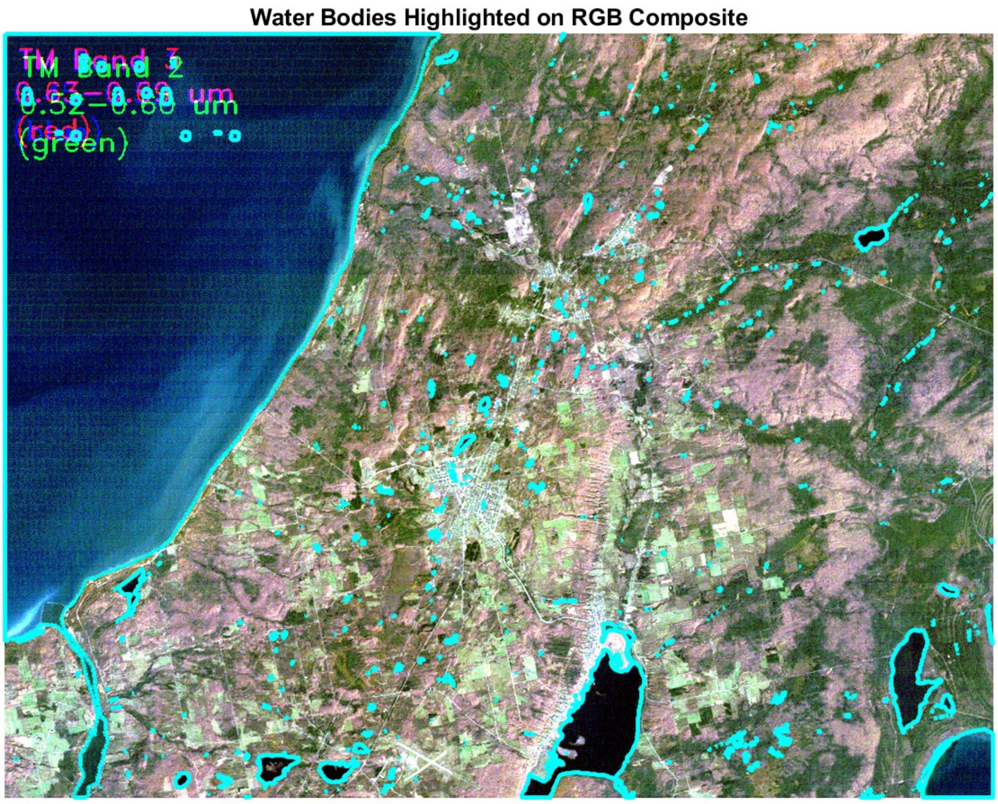

Figure 7: highlighted water bodies

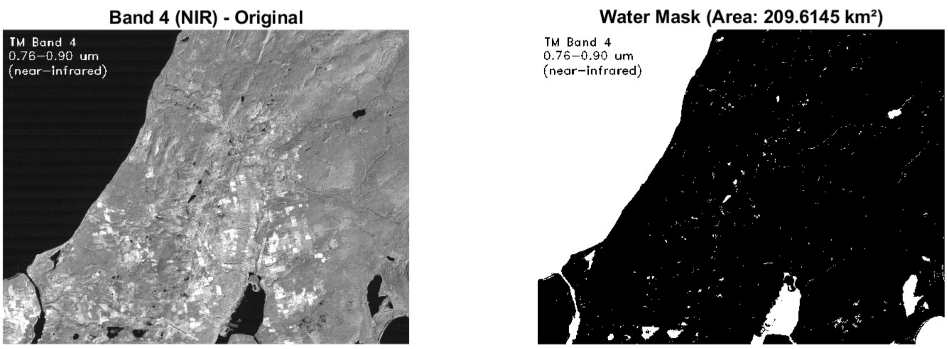

Figure 8: Area of water bodies

Challenge 1. Standard FCC (4-3-2)

An FCC with RGB = (Band 4, Band 3, Band 2) was generated and contrast-stretched. Vegetation appears bright red, facilitating rapid identification of riparian zones and agricultural patches near the coastline. This composite complements natural-color views by exploiting strong NIR–red contrast in healthy vegetation.

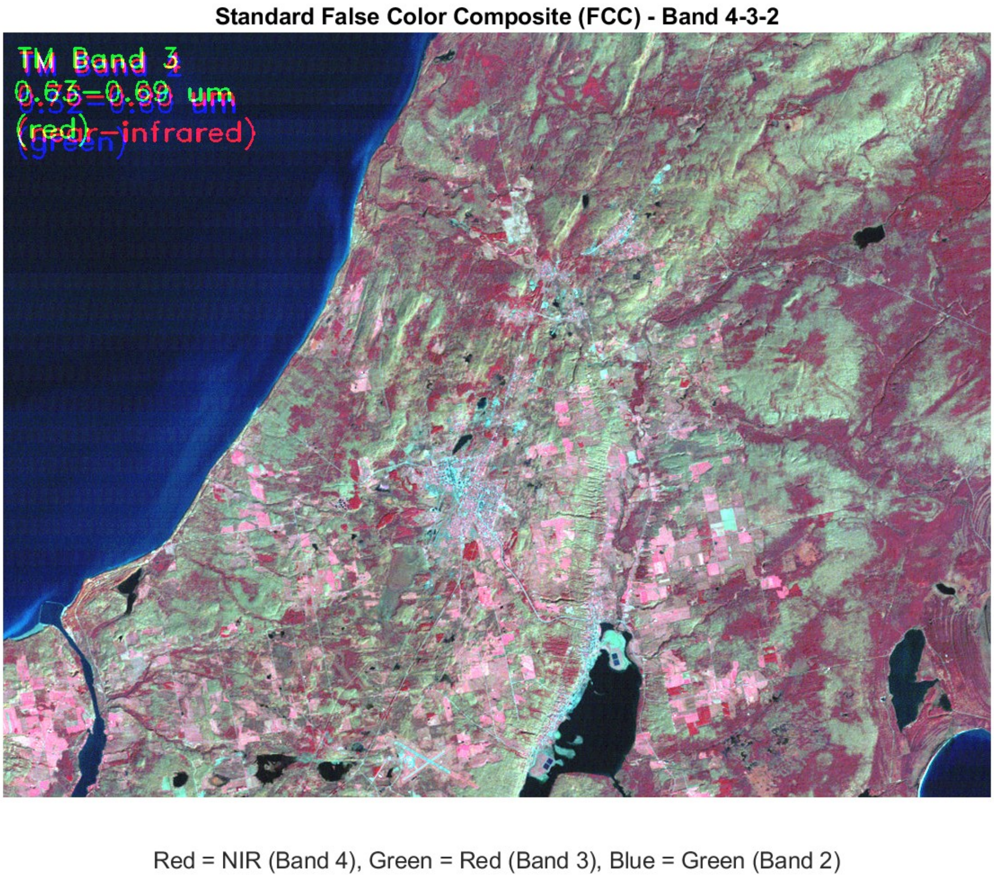

Figure 9: standard FCC image

Challenge 2. PCA on Six Bands

PCA was performed on Bands 1,2,3,4,5,7, and the first three components (PC1–PC3) were reshaped to images with explained variance reported per component. Retaining three PCs yields a 2:1 compression from six bands while preserving most variance. The PC images reveal orthogonal patterns: PC1 captures overall brightness; PC2 and PC3 separate vegetation–soil–water contrasts and lithologic differences, aiding compact analysis and noise reduction. Performing PCA on 6 bands

Principal Component	Variance Explained (%)
PC1	84.26
PC2	6.97
PC3	4.05
PC4	1.79
PC5	1.57
PC6	1.37

Table 1: Variance explained by each principal component.

The total variance explained by the first three principal components is:

$$\text{Total Variance (PC1–PC3)} = 95.27\%$$

Image Compression Analysis:

- Original data: 6 bands $\times$ 935,000 pixels = 5,610,000 values
- Using first 3 PCs: 3 bands $\times$ 935,000 pixels = 2,805,000 values
- Compression ratio: 2:1
- Information retained: 95.27%

This represents excellent compression with minimal information loss.

Challenge 3. FCC of PCs

An RGB composite using PC1, PC2, and PC3 enhances subtle structure and material boundaries not evident in raw bands. This visualization is useful for exploratory mapping and target detection in coastal settings. Color assignments follow R=PC1, G=PC2, B=PC3

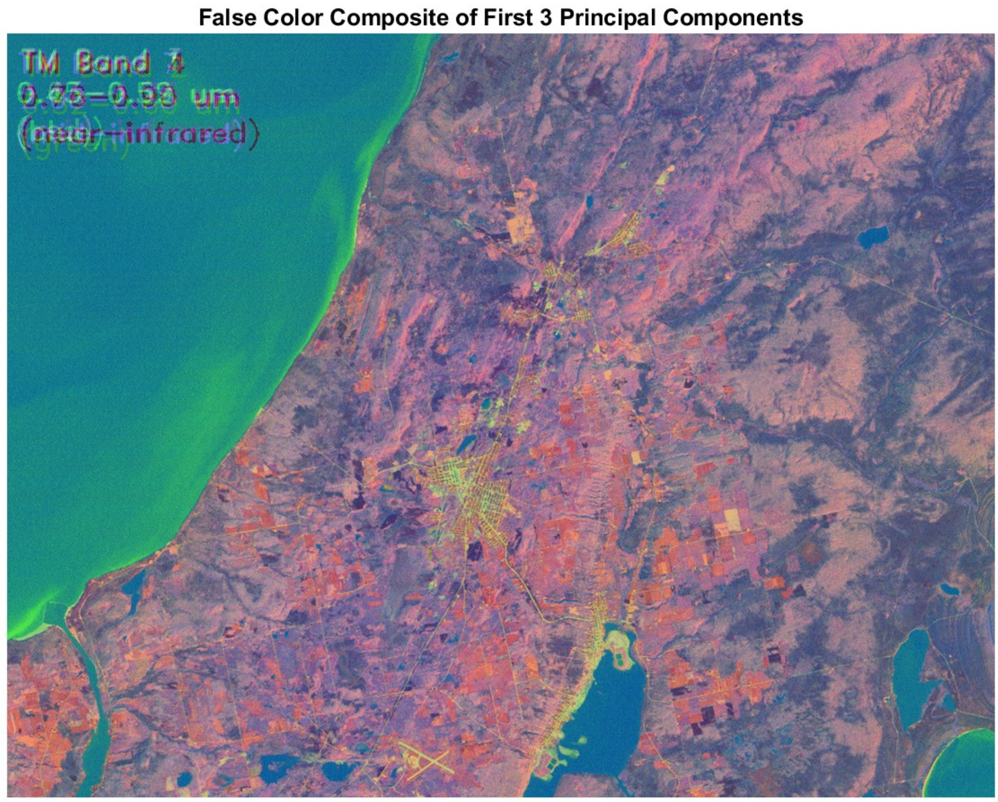

Figure 10: FCC of principle components

Challenge 4. ISH Images

Natural-color RGB (3-2-1) was converted to HSV to extract Intensity (V), Saturation (S), and Hue (H). Separate panels illustrate brightness, color purity, and dominant color angle respectively. These layers help diagnose illumination effects, haze, and material color differences when combined with composites and indices.

- **Intensity:** Represents overall brightness.
- **Saturation:** Indicates color purity.
- **Hue:** Corresponds to dominant color tone.

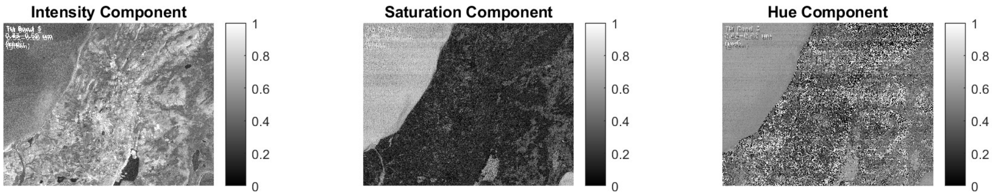

Figure 11: ISH of RGB

Challenge 5. Density-Sliced NDVI

NDVI was classified into five classes with progressively greener tones for vegetation, plus browns for bare/low-vegetation. Class-wise percentages were printed to summarize landscape composition. The two-panel figure includes continuous NDVI and the density-sliced map with legend entries: Water, Bare Soil, Sparse, Moderate, and Dense Vegetation for rapid communication.

Density slicing of the NDVI image is performed using different tones of green. Classification is as follows:

Class Description	**NDVI Range**
Class 1 (Brown): Water / Non-vegetation	NDVI < 0
Class 2 (Light Brown): Bare soil	$0 \leq$ NDVI < 0.2
Class 3 (Light Green): Sparse vegetation	$0.2 \leq$ NDVI < 0.4
Class 4 (Medium Green): Moderate vegetation	$0.4 \leq$ NDVI < 0.6
Class 5 (Dark Green): Dense vegetation	NDVI ≥ 0.6

Table 2: NDVI density slicing classification scheme.

Vegetation Statistics:

- Class 1: 50.69% of image
- Class 2: 34.33% of image
- Class 3: 13.11% of image
- Class 4: 1.43% of image
- Class 5: 0.44% of image

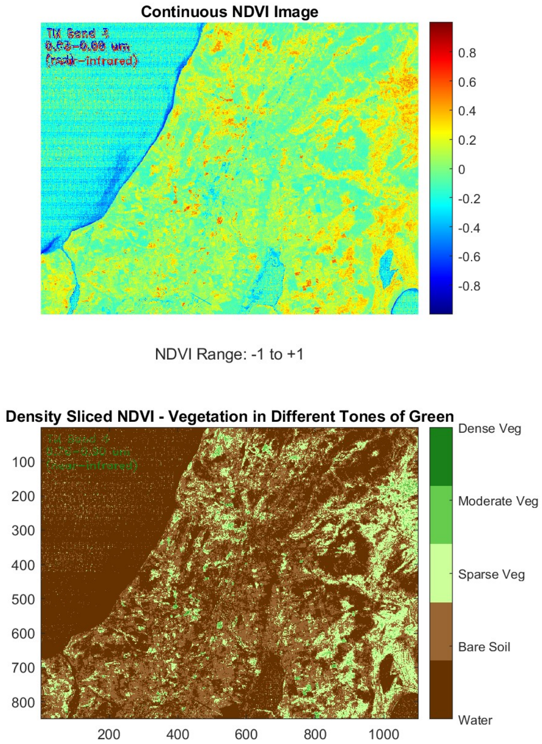

Figure 12: continuous density slicing of NDVI